ANTI-COLLISION TAG APPARATUS AND SYSTEM

The present invention relates to radio frequency identification (RFID) apparatus comprising a reader/writer (later referred to as a 'reader') and transponders (tags).

Such apparatus forms the basis of a radio frequency tagging system, where the number of tags within the field that may be read is limited only by the number of unique combinations of bits used to define a code to identify each tag. Alternatively, two or more tags may define a set with the same combination or part combination of bits and these may be selected simultaneously. Such may be the case when deliberately sending data to tags of the same combination or part combination for the purposes of writing to them or disabling them or otherwise addressing them to modify their functionality.

In operation, an RFID reader will attempt to communicate with one or more RFID tags within the reader's transmission area. The reader transmits a predetermined signal (hereafter referred to as a "field") and then monitors the signal. The tags responding to the signal modulate it in a predetermined manner which is identified by the reader. However, if there are a number of tags within the transmission area it is difficult and time consuming to identify individual tags, communicate with only one tag and even to decrypt their responses to the transmitted signal.

Previous systems have mostly tried to achieve anti-collision of the signals modulated by the tags by incorporating some means to 'talk' to single tags, for example, by binary selection, sometimes by using randomness and helped by the slightly differing times that the tags are introduced into the area, or by beaming (directional control) of the field or by modification

of the field or alternatively by use of complicated algorithms to decrypt overlay data.

These systems are typically hindered by more than one tag 'talking' at the same time.

5　In the past systems have attempted to decrypt overlaying data caused by multiple tags 'talking' at the same time or have relied on random transmissions to separate signals in the time domain or have used a field beam or conduct a time consuming binary search to isolate individual tags. Often tags need to be read twice or even 3 times to confirm there has been no data error.

10　Such a system is disclosed in European patent application number 95112673.9. A tree splitting algorithm is used to identify a tag in a field. Where all tags respond simultaneously, they interfere with each others transmission and the base station receives corrupted data. The tree splitting algorithm organizes and sequences the transmission from tags via a random number generator so that the base station receives data in an orderly manner that is not superimposed and 15　therefore corrupted.

According to an aspect of the invention, there is provided a radio frequency tag apparatus comprising a plurality of tags and a transceiver for sending information to, and simultaneously receiving information from, a plurality of tags without corruption, wherein each tag is allocated 20　an identification word comprising a predetermined number of bits, the tags comprising means for selectively modulating a signal received from the transceiver, and the transceiver comprising means for sending an interrogation signal comprising a plurality of portions, wherein each portion is associated with a predetermined bit, or bit sequence, of the identification words

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used to simultaneously interrogate, substantially at the same time, the tags to identify, in response

to modulated signals provided by the tags, the presence of a tag or tags having a given value at

the predetermined bit or bit sequence.

5   According to another aspect of the present invention, there is provided a method of detecting the

presence of tags within a target area by sending interrogation signals from a transceiver for

selective simultaneous modulation by tags present in the target area, each tag being allocated an

identification word comprising a predetermined number of bits, the method comprising:

sending from a transceiver an interrogation signal comprising a plurality of portions, each

portion being associated with a predetermined bit or bit sequence of the identification words

and being capable of conveying a given value for the bit or sequence of bits, wherein tags

5   having the value at the predetermined bit or bit sequence are configured to modulate the

signal, the modulation being used to identify the presence of those tags.

According to a further aspect of the present invention, there is provided a radio frequency

tag identification system comprising a receiver/transmitter and transponders which are

10   adapted to start communication at the same time and to be simultaneously interrogated and

progressively eliminated from interrogation.

The present invention is directed to an alternative way of interactively isolating tags in a way

that is highly efficient and very fast.

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Operation is such that two or more transponders are capable of operating simultaneously in

the same field in such a manner that information in the form of data bits may be received or

sent to the tags without corruption. This has come to be known as anti-collision.

20   In contrast to previous systems, the present invention will not work unless the tags are

allowed to 'talk' at the same time and uses positively 'collision' rather than trying to avoid

it.

Moreover, the system of the present invention described is self-checking. Not only does the

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reader check the tag output but the tag also checks the reader output. and will drop out in the case of an error. This self check means the tag need only be read once and is secure.

The invention will now be described by way of example only, with reference to

5   accompanying figures:

Figure 1 is a data bit stream for use in an apparastus in accordance with the invention;

Figure 2 is another data bit stream for use in an apparatus in accordance with the invention;

Figure 3 is another data bit stream for use in an apparatus in accordance with the invention;

10   Figure 4 is a block diagram of an RFID 'reader' for use in an apparatus in accordance with the invention; and

Figure 5 is a block diagram of an RFID 'tag' for use in an apparatus in accordance with the invention.

15   In an embodiment of the invention all active tags are requested to start communicating at the same time, forming a 'collision' and are simultaneously interrogated and progressively eliminated. Communications from the tags are synchronised by, in this case, a search pattern, but this may be by any other form of synchronisation.   Tags that do not receive a valid search pattern do not send data at all.

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The invention might be better thought of as Synchronised Collision. It is normal for a reader to communicate to the tag using 100% modulation of the field. To start a search pattern, the reader transmits a data pattern called a 'Start Search Pattern'. This is understood by all tags as a start search command. There is another pattern known as a 'New Sweep Pattern' which

signals a new sweep within the overall search. Each sweep represents a single interrogation of the tags winthin reach and a number of sweeps equal to the number of tags plus one are needed to identify the presence of each individual tag. A search will generally consist of as many sweeps as there are tags in the field and an additional final sweep that may be aborted

5   when no tags respond. The above "start search" and "new sweep" patterns in this example are detected by their duration but may be any compatible distinguishable pattern.

Tags are only allowed to participate in a search if they have received a 'Start Search Pattern'. This among other things, prevents late arrivals from disrupting the search. After the valid

10   reception of a start search pattern, the tag is said to go active. The reader next transmits the interrogation pulse sequence. In this embodiment, the length of the pulse determines the binary value of the interrogation pulse, but alternative encoding schemes such as pulse code modulation may be used. The tag employs amplitude modulation, however, alternative methods such as phase shift keying may be used.

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A 'search' will consist of a number of 'sweeps'. Each sweep will select an individual tag or set of tags sharing the same address. A normal sequence of a search of tags of different addresses will be shown below. Three states are referred to. These are 'Active' in which case the tag will participate in the search. 'Quiescent' in which case the tag is waiting for another

20   sweep, and 'Inactive' in which case the tag has either not received a 'Start New Search' pattern or has already participated in a search and been eliminated (written to and/or read).

The sequence of steps for identifying tags in a field is as follows;

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(a) A 'Start Search Pattern' is transmitted by the reader to alert all tags in the field that a search is to follow:- all tags in range go 'active'.

(b) A sequence of interrogation pulses (portions) corresponding to the number of bits, or sequences of bits, of the tag identification word, or else a reduced number if a set is to be identified, is sent out by the reader to which active tags interactively respond and all but 1 tag (or a set of tags sharing an identical address) is eventually eliminated. Data may be written to any tag/tags selected. Any tag so selected will then go inactive until the next 'Start Search Pattern'. Tags failing to be selected on a bit by bit (or bit pattern by bit pattern) basis go quiescent the moment they fail such an interrogation.

10   (c) A 'New Sweep Pattern' is transmitted by the reader – all tags in the quiescent state go active again. Tags that have not received a 'Start Search Pattern' or have already been selected (read) remain inactive.

(d) The reader loops back to 'b' above. At n +1 loops the reader detects no further tag interaction and ends the current search.

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After transmission of a 'Start Search Pattern' the reader sends out a pulse. As the pulse duration increases, it passes through a period in time named the 0 modulation window (MW-0) in which all active tags which have a 0 in the first bit position must reply by turning on their modulator thus modulating the field. In the absence of a detectable response the reader

20   will continue the duration of the pulse. As the pulse duration increases it passes through another period named the 1 modulation window (MW-1) in which all active tags which have a 1 in the first bit position must reply by turning on their modulator thus modulating the field. (Later it will be explained how bit patterns (such as 00,01,10,11) can be substituted for the individual bits.)

An example of a start search pattern followed by the transmission of three MW-0 windows, as transmitted by a reader, is shown in Figure 1.

In this embodiment, a tag will always be asked if its next bit is a 0 before it is asked if its

5   next bit is a 1. Where more than one tag replies by modulating the field at the same time, the modulation of the field is increased. Logic within the reader will normally, upon the detection of modulation appearing in a MW-0 window, not extend the pulse to transmit a MW-1 modulation window. Where the MW-1 modulation window is not transmitted, any active tag that has a 1 in that position is programmed to go quiescent until a 'New Sweep

10   Pattern' is received. In the instance that no active tag has a '0' in this position, the reader will extend the pulse up to the '1' position and all the active tags with a '1' in this position will remain active. The gap between the reader pulses is used by the tag to sequence the progress through the bits. The reader transmits the next interrogation pulse and so on. In this way the reader can conduct a highly efficient binary elimination, such that it needs only

15   a 'Start Search Pattern' or a 'New Search Pattern' followed by as many pulses as there are bits in the tag type.

In this embodiment no distinction is made between tag data and the tag address. Tag data, if present, may be placed at the end of a tag address or alternatively in addressable blocks.

20   Once a single tag has been isolated, the same process could be repeated to read any tag data, if present, however once the possibility of collisions has been eliminated, tag data can then be read in a more conventional way such as Manchester encoding or Phase shift modulation. The key point in this invention is the self checking 'anti-collision' method of isolating a single tag (or set of tags of the same address or part address) by the method described.

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A tag may receive a start search pattern or a new sweep pattern and participate yet be out of the read range of the reader. In this instance the tag itself detects an apparent inconsistency in the reader transmissions. For example a tag which has just modulated a 0 window will expect the pulse to terminate instead of going on to the 1 modulation window.

5 In this case the tag will go quiescent and wait for a new sweep pattern. This is a self-check and is a system advantage.

When a single tag or set of tags has been successfully isolated and identified, the reader may also write data to it (assuming the tag has EEROM or EPROM). Once read, the tag may be

10 pre-programmed to remain silent until either the field is removed or it receives a new 'Start Search Pattern'. The reader will usually next transmit a 'New Sweep Pattern' and continue reading and eliminating tags until none remain. The 'New Sweep Pattern' wakes any tag in the 'quiescent state' that has been eliminated, but not read, from a previous sweep, allowing it to participate in the next sweep. Each sweep will normally identify a unique tag hence

15 there will usually be as many sweeps as there are tags in the field, and a last sweep that will produce no results and may be aborted early.

The reader begins by sending a search pattern. The reader next starts to transmit a pulse. If no tag modulates the 0 window of the pulse, the reader will deduce that there is no active

20 tag in the field that has a 0 in the first bit position. In this case the reader would continue the pulse to include a 1 modulation window. Any tag in the field with a 1 in this position will start modulating in this window and will continue to be active. In the instance of the first bit, ·if neither window is modulated the reader will deduce that there is no tag in range.

Assuming the first bit is modulated in the 0 modulation window (MW-0) and the reader

stopped the pulse before the 1 modulation window, any tag with a 1 in this position will go

quiescent until either a 'New Sweep Pattern' or a 'Start Search Pattern' is received. The

reader continues onto the second bit and so on until it gets to the last bit position and an

5   individual tag (or set of tags) has been isolated. After a tag has been identified and eliminated

the reader will start a new sweep. (The significance of mentioning a 'set of tags' lay in the

possibility that a special set of tags can be switched off, or if the facility allows, be written

to, or otherwise made to perform in a special way. A further type of reader modulation may

be inserted – say by a pulse extending beyond the 1 modulation window or an extra mini

10   pulse – to let the set know it has been selected.)

In this fashion the reader will detect a 64 bit tag every 64 bit pulses (not including the 'Start

Search Pattern and the 'New Sweep Patterns'). This is a highly efficient algorithm.

15   Figures 2 and 3 show a received signal at the reader, in response to a signal transmitted by

the reader and modulated by tags.

Referring to Figure 2, it will be seen that pulses A, B and C have all been modulated in the

'0' modulation window (MW-0). This is represented by the fall in the signal level following

20   the MW-0 signal. This shows that there is at least one active tag in the field having a '0' in

the first three bit positions. The 'Start Search Pattern in fig 1 is shown as a long pulse by

example. In practice a long break in the field is more usual. This resets all tags.

In Figure 3, it will be seen that the first pulse (A) has been modulated by at least one tag

which has a '0' in the first position. The second interrogating pulse (B) shows that no active

tags have a '0' bit in this position. As a consequence the reader has continued the pulse to

allow active tags with a '1' in this position to respond and modulate the '1' modulation

window and stay active. In this way tags are progressively read and eliminated.

5   In this embodiment modulation of the field by the tags is amplitude modulated (ASK) but

phase modulation (PSK), frequency modulation (FSK) or any detectable form of modulation

may be employed.

In this embodiment individual bits have been interrogated for simplicity, although   bit

10   patterns can be interrogated such as 00, 01, 10 or 11 and so on. In the instance of the

following bit patterns, 00,01,10,11 this can be achieved by using 4 possible modulation

windows representing the 4 possible combinations. The operation will be then carried out as

before. The first modulation window could be 00. Any active tags having this bit pattern at

this stage of the prosecution of the interrogation will be required to modulate this window

15   and remain active. This will eliminate tags having bit patterns 01,10 and 11. Should no tags

have a 00 pattern then the reader will extend the pulse to include the next modulation window

and so on as in the case of detecting '0' and '1' bits. Because the reader need not modulate

the field as many times, there is some speed advantage. As the bit pattern is increased

beyond 2-3 bits it will be increasingly more difficult extract a speed advantage and if the bit

20   pattern is made still larger the overall speed will eventually diminish.

Figures 4 and 5 are block diagrams of conventional apparatus configured for use in the

present invention.